BROOKHAVEN NATIONAL LABORATORY **APPENDIX 13**

MEMORANDUM

DATE: June 18, 1992

TO: S. Musolino

FROM: W. R. Casey

SUBJECT: Review of RHIC Design Criteria for Prompt Radiation

As you requested S&EP has completed its review of your proposed SAR - Section 3.9.2 Design Criteria for Prompt Radiation for RHIC. This final version dated 6/9/92 has incorporated all S&EP's previous comments and therefore I concur with your design criteria.

SE3220.92
Attachment

cc: H. Kahnhauser
O. White

DOE F 1325.8
(8-89)
EFG (07-90)

United States Government **Department of Energy**

memorandum

DATE: MAR 24 1993

REPLY TO ATTN OF: ER-23

SUBJECT: Independent Safety Review of the Relativistic Heavy Ion Collider Project-December 2-3, 1992

TO: David L. Hendrie, ER-23

The Accelerator Safety Order (ASO), DOE Order 5480.25, requires (Sect. 9e) "An independent review of the provisions for personnel safety and health shall be conducted by a DOE-appointed ad hoc panel of technical experts during the design phase of each new accelerator facility of moderate- or high-hazard class...". The Hazard Classification of the Relativistic Heavy Ion Collider (RHIC) facility at the Brookhaven National Laboratory (BNL) has not yet been designated by the Office of Energy Research, but because of the size and significance of the RHIC project, the Division of Nuclear Physics felt it advisable to conduct an early independent safety review; to this end a committee was established (See Attachment I for a list of the members). The Independent Safety Review was conducted at the RHIC project on December 2-3, 1992. The review consisted of technical presentations by RHIC and Brookhaven staff and a tour of the existing facilities. The meeting agenda is given in Attachment II. Brief summaries of main points of the presentations and a list of suggestions for future activities in the area of personnel safety and health proposed by the review committee are given in this report. As an overall assessment, the committee found that the start of a comprehensive and appropriate effort in the area of Environment, Safety, and Health (ES&H) for the RHIC facility has been made by the RHIC project and Brookhaven management. There appears to be a strong commitment to build a sound (ES&H) program on this start.

Background:
S. Ozaki, RHIC Project Head, presented an overall background description of the project. The total facility comprises four accelerators and related transfer lines and a large helium refrigeration system. Of these, a tandem Van de Graaff, a synchrotron booster, the Alternating Gradient Synchrotron, and two transfer lines already exist. The AGS-RHIC transfer line and the collider ring will be installed in the existing tunnel at Brookhaven originally built for the Colliding Beam Accelerator (CBA) project. About 90 percent of the RHIC civil construction has been completed. The Safety Analysis Documentation for the AGS complex has been drafted to comply with the ASO. The existing three accelerators were not considered in any detail during this review. A Preliminary Safety Analysis Report for the collider ring and transfer line from the AGS to the ring has been completed. The project is scheduled for completion in FY 1997. At present, all contracts have been let for the superconducting dipole, quadrupole, and sextupole magnets which will be built by private industry. Installation of the collider ring components will begin in FY 1994. The existing refrigeration system will also be restarted in FY 1994. In FY 1995 the AGS-RHIC transfer line and the first sextant of the ring will be tested at low intensity.

Overview of ES&H Program:
S. Musolino, Assistant to (RHIC) Project Head for ES&H presented an overview of the ES&H program. At present there are three FTE's dedicated to the RHIC project with responsibility for ES&H management and program coordination, security systems engineering, training and documentation. There are also three FTE's from the BNL Safety and Environmental Protection Division who work full time in the project. These personnel are mostly involved in program development, and as the project evolves the staffing will be increased. There are six internal safety review committees reporting directly to the RHIC project director within the RHIC project with responsibility to review 1) prompt radiation safety, 2) safety of experiments, 3) conventional safety of accelerator systems, 4) ALARA, 5) "hot" work oversight, and 6) self-assessment activities. Cryogenic safety and ES&H standards are reviewed by separate committees that report to the Project Head. There already exist a BNL-wide set of ES&H policies and procedures manuals. RHIC-specific Policy and Procedures manuals and Operations Procedures Manuals which conform with the laboratory requirements have been issued. There is in place an OSHA compliance program under the RHIC ES&H coordinator, involving weekly walkthroughs. Monthly meetings are held with first line supervisors to discuss the weekly activities, external and internal audits, current topics etc.. The managers are expected to hold meetings with their staffs to discuss the topics from the monthly meetings. There is a particularly strong program in electrical safety, which includes a safety work permit program, a lock-out tag-out program, and a documented worker training program, all adapted specifically to RHIC operations.

Life Safety: The RHIC facility will be constructed and operated in full compliance with DOE 5480.7 (Fire Protection) and DOE 6430.1 (General Design Criteria). The Preliminary Safety Analysis Report (PSAR) indicates sprinklers will be installed in the ring tunnel. Since the completion of the PSAR, the RHIC project has proposed that, in accordance with the NFPA standards, sprinklers are not necessary in the tunnel. The BNL request to eliminate the commitment to install sprinklers in the tunnel has been concurred in by BHO, CH, and ER-8. There remains to be done some renovation of work done in the tunnel that was completed 10 years ago, and there remains to be completed Safety Analysis Documents (SAD) for the experimental areas around the ring. There does remain some question about the use of flammable material in hydraulic equipment in the tunnel, and of fire limiting materials in cable trays (see committee recommendations below).

Environmental Compliance:
The following summarizes the status of the RHIC project with respect to relevant environmental agencies.

National Environmental Policy Act (NEPA)- An Environmental Assessment has been prepared and a Finding of No Significant Impact Issued. No further action is required

Air Quality- A NESHAPS (National Emission Standards for Hazardous Air Pollutants) permit has been issued. There may be requirements for permits from the New York Department of Environmental Conservation required, but this can only be done as the project progresses, and specific potential sources can be identified

Wetlands and Water Quality-All possible requirements in this area have been investigated, and in all but one case appropriate authorizations or exemptions have been issued by the involved federal or state agencies. Construction permits from the New York Department of Environmental Conservation under Article 24 of Environmental Conservation Law will be required to complete construction of the tunnel, to regrade the tunnel berms, and to construct some additional facilities. There are no anticipated delays in obtaining the required permits.

Endangered Species- The U.S. Fish and Wildlife Service has concurred in a finding that no federally listed or proposed endangered species occupy the RHIC site. A request for a similar finding has been submitted to the State of New York, and no problems have been identified or are anticipated.

Historic/Archaeological Preservation- The New York State Historic Preservation Officer has issued (1/2/91) a determination of no impact by the RHIC project on areas/materials of historic/archeological interest.

Hazardous Materials Storage- No sites or facilities for storage of hazardous materials have been identified at the RHIC project. If such sites are required, the requisite permits from the state and from Suffolk County will be obtained.

Hazard Classification:
The ASO requires that the Hazard Classification of a proposed accelerator facility be determined from an analysis of all possible hazards which might occur when the facility is in operation, and that this Hazard Classification be formally designated by the relevant Program Secretarial Officer. The level of approval of various stages of the development of the facility and the level of detail required in the Safety Analysis Document for the facility are determined by this designated classification. The accelerator facilities which together serve as an "injector" to the collider ring are already operating, and they will ultimately have to be brought into compliance with the ASO according to backfitting procedures spelled out therein. The RHIC project has made a hazards analysis of the AGS-RHIC transfer line and all segments of the collider ring except the experimental halls. They have determined that the facility is a low hazard facility. In making this analysis and determination, the criteria and procedures contained in DOE Order 5481.1b-Safety Analysis and Review System and in DOE Order 5480.25-Safety of Accelerator Facilities were used. The recommended Hazard Classification has been approved by BNL management. The existing safety Analysis Report for the helium refrigerator system will be folded into the sections of the RHIC SAD which is being prepared for the cryogenic system.

Design Criteria for Prompt Radiation at RHIC Site:
The RHIC Project has adopted a set of design criteria from prompt radiation in the RHIC facility area. They define four classes of areas-areas of high occupancy (2000 hours/year) for radiation workers and non-radiation workers, and areas of low occupancy (1/2 hour per 8-hour day) for radiation and for non-radiation workers. For each of these four classes of areas they propose design-allowed radiation exposures for normal operation and for the design basis accident (see Attachment III). The criteria for normal operation are all well within limits specified by applicable federal and state

regulations. There are no similar limits for accidental exposure in any existing orders. The proposed design basis limits for exposures to radiation workers due to faults are all comparable or slightly in excess of allowable annual exposures from normal operation for radiation workers. For non-radiation workers, the allowable "fault" exposures are comparable to background. The committee raised no objections to the proposed design criteria

Radiation-exposure Levels Around the RHIC Facility:
An extended series of presentations was made on mechanisms for and the magnitude of beam losses in the AGS-RHIC transfer line and the collider ring. The maximum credible accident in the ring was defined as the loss of all the beam bunches on one limiting aperture. In the transfer line, the maximum credible accident has been assumed to be the loss of all beam on a magnet at normal RHIC intensity, and that the beam in the transfer line is interlocked off after two AGS pulses. The calculations of the expected radiation exposures around the RHIC facility based on the proposed beam losses in normal and fault conditions at the surface of the shielding berms, at a variety of locations in the tunnel, and through a number of penetrations in the tunnel were described. For most cases and areas, the resulting exposures satisfied the design criteria, but several areas were identified where there will need to be increased shielding and/or access control. The members of the committee found no fault with the calculations, given the beam loss scenarios. There is a serious question about the maximum credible accident scenario for the AGS-RHIC transfer line. It will be possible to develop a proton beam in the AGS ring with an intensity that is 25 times greater than the proton intensities appropriate for the RHIC ring. BNL has assumed that the AGS will never operate at the high intensity when it serves as an injector to the RHIC, and that this will be assured through a combination of administrative and engineered controls. Since there will be a physics program which involves using the AGS by itself in the high intensity mode, there remains the possibility that this high intensity beam could be steered in to the AGS-RHIC transfer line by fault. Should such a fault occur, calculations estimate that fields on the order of 300 R/hr would be produced at the surface of the dirt shielding over the transfer line. (See recommendations below).

Cryogenics:
The helium refrigeration system was built over ten years ago for the CBA project, and is complete and in a standby mode. A chapter for the RHIC Safety Assessment Document SAD is being prepared. Much of this work involves an upgrade of a previously existing SAR document. Because of the age of the existing structure, it will be necessary to evaluate the condition of much of the equipment, and it may be necessary to upgrade some of that equipment. Present plans are to put the facility back in operation in FY 1994, to cool the first sextant of the ring in FY95,and to cool down the entire ring in November 1996. None of the system to distribute the refrigerant to the ring components is in place, and little analysis of that system has been done.

There exists an ongoing Brookhaven National Laboratory Cryogenic Safety Committee, and they have held a series of reviews of the designs of the cryogenic RHIC arc dipole magnets. At its last meeting the committee approved the design of the magnet subject to satisfactory qualification of

the welding procedures and the welders. There was a detailed discussion of research on the development of welding material that is appropriate at the 4K temperatures which will be realized in the dipoles- appropriate materials are now available. An independent review of the welding procedures and materials has been conducted by Grumman. The Grumman review concurred in the proposed procedures.The prime contracts for the construction of the arc dipoles have been let.

Committee Comments and Recommendations:
Design Criteria for Prompt Radiation at RHIC- The committee had no objections to the design criteria for radiation exposure at RHIC. As indicated above, the committee was concerned about the assumed maximum credible fault in the transfer line. The scenario assumes that through a system of beam intensity monitors, interlocks, and administrative controls, the high intensity proton beam in the AGS ring has an "extremely low" probability of crossing over in to the AGS-RHIC transfer line. The draft ER guidance for the Accelerator Safety Order allows credit for engineered safety features if they can only fail in a fail-safe manner. A more detailed analysis of the protection system is needed to support this position.

The accelerator radiation safety community has traditionally taken the maximum credible prompt radiation accident for design purposes to be (in the absence of other information to the contrary) the spill of the full power of the accelerator at the regions of the thinnest shielding and that the maximum beam spill continues for an hour. Less severe criteria might be appropriate for accelerators where the spill cannot be sustained for an hour by physical limitations such as the quenching of a super conducting magnet system. BNL has the burden of proof for showing that this scenario, which is physically possible, is, in fact, of such low probability as to be incredible. The arguments presented to show that this scenario was incredible were not totally convincing to the committee.

Recommendation: More details of the personnel safety system at the RHIC facility must be developed, and the proposed scenario for ensuring that the maximum credible accident in the transfer line is an event of "extremely low" probability should be evaluated.

Hazard Classification- The hazards analysis and low hazard classification of RHIC has been approved internally. The committee found no fault with the existing analysis, with the exception of the assumed scenario for the maximum credible accident as noted above. The analysis does not include the experimental halls or the refrigerator, and the hazards classification of RHIC has not been submitted to DOE with a request that it be accepted by the PSO.

Recommendation: The hazards analysis of RHIC should be completed to include the experimental halls (with or without detectors), the refrigerator, and the liquid helium distribution system, and a request for the designation of the hazard classification of the entire facility be submitted to the DOE as soon as practical.

Construction Safety- The RHIC project is approaching a period when there will be a significant number of non-contractor workers on-site involved in

assembling the collider ring and other construction projects. A consistent weakness found at many of the DOE facilities during the recent Tiger Team appraisals and other similar reviews is sub-contractor worker safety. The committee heard a presentation of the BNL program for sub-contractor worker safety and was favorably impressed with it.

Recommendation: The RHIC project should develop a program for sub-contractor worker safety which closely emulates the laboratory program and should carefully plan the implementation of this program in anticipation of entering this construction stage.

Injection Current Monitors: Key component(s) in the personnel safety system will be the injection current monitor(s) in the transfer line between the AGS and the collider ring. The design of the monitor and its positioning in the system was discussed with the committee. The RHIC project has not yet developed plans for current monitors in the AGS-RHIC transfer line.

Recommendation: Current monitors should be included between the transfer line and the switcher magnets to the collider ring as part of the personnel safety system to protect against the injection of excessive current into the RHIC ring.

As has been stated several times, a good start has been made towards planning for safety, but this planning and implementation is still in the very early stages. The committee urges that the following considerations be factored into the development of the safety program.

Site Access- As of this time, there is no meaningful control of public access to the collider ring area- thus there is no distinction between on-site and off-site. In light of the new DOE Radcon Manual, there could be significant training, posting, etc. requirements. Consideration should be given to the use of fences at key areas around the site to reduce these requirements.

Oxygen Deficiency Hazards (ODH)- The safety of the helium distribution system has not yet been fully analyzed. During the walking tour of the collider tunnel, it was noted that there was an opportunity for a loss of helium at a personnel exit point which could lead to a very hazardous condition, and part of this problem was created by the positioning of exhaust fans required for fire safety purposes. The hazard potential at these exit sites should be carefully considered from both an ODH and a fire safety viewpoint.

Prompt Radiation from Muons- The potential radiation hazards from muons has been analyzed, but the positioning of ring components has now been changed, and this analysis should be reviewed.

Fire Safety- In accordance with NFPA codes, concurrence has been reached between BNL, BHO, CH, and ER-8 that sprinklers are not required in the tunnels of the collider ring. In light of this, a program should be developed to ensure that the transient fire load (pallets, packing

materials, boxes, etc.) should be kept to a minimum. Although sprinklers are not required in the tunnels,serious consideration should be given to installing sprinklers in the Labyrinth Hallway from Building 1005S to the RHIC tunnel, and in the "Magnet Tunnel" as identified on BNL drawing 7003-1001 the Switch Yard and the area between Match Line C and Match Line Z.

There remains an inconsistency between the PSAR and the agreement reached not to require sprinklers in the RHIC tunnels. The PSAR still allows the possibility of using combustible sheathed cables in the tunnels if vermiculite filled pillows are installed as firestops. The agreement not to sprinkler was based on the assurance that combustible sheathed cable would not be used. This inconsistency should be rectified in the final SAD.

The final fire safety concern was with regard to the use of hydraulic equipment in the tunnels. Only Factory Mutual approved safe fluids should be permitted for use in this equipment.

Joseph B. McGrory
Chairman
RHIC Independent Safety Review Panel

cc:
Committee Members
Jim Yeck, BHO
Joseph Maher, ER-8
Daniel Lehman, ER-65
Clarence Richardson, ER-23
Judy Keating, NS-1

Attachment 1

Independent Safety Review of RHIC Project

December 2-3, 1992

Panel Members

Howard Casebolt	Fermilab
John Harris	SLAC
Robert Macek	LAMPF
Klaus Rode	CEBAF
Dave Goodwin	DOE/ER-20
Joe McGrory (Chair)	DOE/ER-23
DeVaughn Nelson	DOE/ER-8
Richard Diem	DOE/BHO
Jim Merutka	DOE/CH

INDEPENDENT SAFETY REVIEW OF RHIC

Brookhaven National Laboratory
Building 1005S, 3rd Floor Conference Room
December 2-3, 1992

Agenda

December 2, 1992

0800-0830	Executive Session	
0830-0835	Welcome	S. Ozaki
0835-0840	Opening Remarks	J. McGrory
0840-0915	ES&H Program Overview	S. Musolino
0915-0930	Life Safety and Fire Protection	J. Levesque
0930-0945	Status of Environmental Compliance	T. Sperry
0945-1000	RHIC Hazard Classification	S. Hoey
1000-1015	Coffee Break	
1015-1045	Beam Loss Scenario	M. Harrison
1045-1200	Tour of RHIC Site	TBA
1200-1330	Lunch	
1330-1415	AGS-RHIC Transfer Line Shielding Analysis	A. Stevens
1415-1500	Shield Penetrations Analysis	P. Gollon
1500-1515	Coffee Break	
1515-1545	Design Criteria for Prompt Radiation Limits on the RHIC Site	S. Musolino
1545-1615	Injection Current Monitors	E. Zitvogel
1615	Executive Session	
1800	Dinner	

December 3, 1992

0830-0900	Executive Session
0900-0915	Planning Overview of RHIC Personal Safety System ..... R. Frankel
0915-0945	Planning Overview of Beam Abort System ..... H. Foelsche
0945-1015	Planning Overview of the Cryogenic System ..... D. Brown
1015-1030	Coffee Break
1030-1100	Safety Issues on Cryogenic Magnets ..... S. Kane/A. Prodell
1100-1200	Arc Dipole Cold Mass Safety Analysis ..... S. Mulhall
1200-1300	Lunch
1300-1430	Executive Session
1430-1500	Closeout ..... J. McGrory

11/20/92

Area Classifications

- High Occupancy - 2000 hours per year
- Low Occupancy - 1/16 (1/2 hour/8 hour day)
- A: Radiation Worker; high occupancy
  B: Radiation Worker; low occupancy
  C: Non-Radiation Worker; high occupancy
  D: Non-Radiation Worker; low occupancy

Attachment 3

Design Criteria

- Class A
  - -Normal Loss 0.2 mrem/hr
  - -Fault 500 mrem/yr
- Class B
  - -Normal Loss 3.2 mrem/hr
  - -Fault 1000 mrem/yr
- Class C
  - -Normal Loss 15 mrem/yr
  - -Fault 10 mrem/hr
- Class D
  - -Normal Loss 240 mrem/yr
  - -Fault 160 mrem/yr

BROOKHAVEN NATIONAL LABORATORY

MEMORANDUM

DATE: November 7, 1996

TO: M. S. Davis

FROM: W. R. Casey WRC

SUBJECT: **Review of RHIC Design Criteria and Applicability to 10CFR835**

A controversy has developed during the Laboratory ES&H Committee review of the RHIC SAD. The question under discussion "is the analyzed fault condition which generates a maximum radiation exposure of 160 mrem compliant with 10CFR835 requirements that exposures in uncontrolled areas not exceed 100 mrem effective dose equivalent?"

The S&EP Health Physics Group has reviewed the applicability of 10CFR835 to the RHIC Design Criteria as specified in the draft RHIC SAD and as published in Health Physics (March 1994, vol. 66, number 3) for the Design Basis Accident, DBA. It is our opinion that RHIC design criteria of 160 mrem on the berm as the result of a DBA is outside the scope of 10CFR835. We believe this opinion is consistent with DOE commentary. We base our opinion and our understanding of Part 835 and on the commentary provided by DOE when the Part 835 was published (FR vol. 58, no.238, p 65481-82).

DOE has explicitly discussed in these comments that the design objectives of 10CFR835 are applicable to occupational exposures of workers in DOE facilities during routine operations. A DBA, by its very nature, cannot be considered a routine operation. Part 835 only addresses accident and emergency doses with regard to emergency dose limits to workers whose action is necessary to prevent major loss of property and lifesaving operations. Neither of these cases are applicable to the RHIC DBA design criteria.

We believe that the RHIC design criteria is highly conservative for the following reasons:

1. The design assumes that the full beam is lost on a single RHIC element. Actual experience at Fermi and elsewhere is that the beam will be lost over several elements. This effect would be to reduce the calculated dose on the berm top proportionately.
2. The calculated dose assumes that the weighted neutron quality factor will be doubled by DOE or other standard setting agencies in the future. While this is a prudent decision, it currently results in a doubling of the neutron dose that would be assigned in an accident.
3. The probability of full beam loss at maximum beam intensity is considered a low probability event, certainly on the order of once per year or less. Actual experience at FERMILAB has been on the order of once in seven years. This probability, coupled with the requirement that an individual would have to be directly above the point of loss on the 2.5 mile circumference leads us to conclude that the likelihood of an individual receiving any exposure during the DBA is quite remote.

This analysis was discussed with the PAAA Coordinator in the DOE/CH office and the unofficial opinion was in agreement with our position on the applicability of 10CFR835 for the above reasons. Although we believe that there is no applicability of 10CFR835 we agree with the RHIC Project that DOE Order 5400.5 and the soon to be published 10CFR834 are the most applicable document for the DBA design criteria.

HP3020.96

cc: D. Lowenstein
S. Ozaki
D. Rorer
E. Lessard
S. Musolino
K. Reece
R. Miltenberger
M. O'Brien
R. Selvey (ESH Committee)

BROOKHAVEN NATIONAL LABORATORY

M E M O R A N D U M

DATE: November 22, 1996

TO: S. Ozaki

FROM: M. S. Davis

SUBJECT: Applicability of Part 835 to RHIC to Fault Conditions Analyzed in the RHIC Safety Analysis Document

Based on the information provided to me and the analysis of the issue by SEP, I concur that Part 835 does not apply to the fault condition analyzed in the RHIC Safety Analysis Document. This issue has also been discussed informally with the Price Anderson Act Amendment Coordinator at DOE Chicago, who expressed the same position that Part 835 does not apply to this condition.

cc: R. Casey
H. Kahnhauser
T. Kirk
D. Lowenstein
R. Miltenberger
S. Musolino
M. O'Brien
K. Reece
D. Rorer

c: SND doc